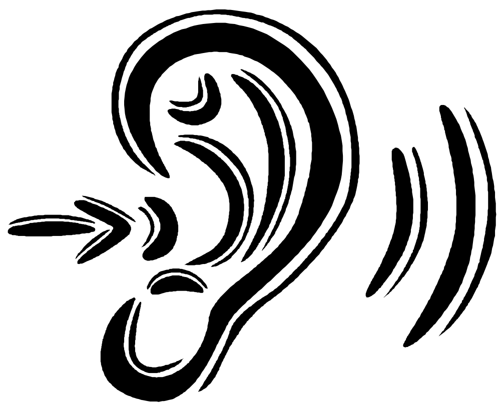
centre de développement pédagogique
pour la formation générale en science et technologie



If walls could talk…

Student booklet

WORKING DOCUMENT

March 2009

Context

You are a part of a spy brigade.
For the ends of your inquiry, you must be able to hear something that is transmitted on a sound track that at first glance appears…inaudible!

You will have to design a listening device to succeed. How will this device work?
How does sound travel?
How does the human ear work?

Here are questions to which you must certainly find the answers to bring your mission to term…

Secret agents, good luck in your mission!

Specifications booklet needed for designing a listening device

Global function:
The device will have to allow for an audio message, broadcast inside a box, to be decoded.

In terms of the *human aspect,* the listening device must:
- Be attractive, lightweight, not cumbersome and safe to use*;
- Allow the user to listen while respecting a safety perimeter of one meter around the box broadcasting the message.

* Be careful! The eardrum is a fragile membrane!

In terms of the *physical aspect,* the listening device must:
- Be made from tough materials.

In terms of the *technical aspect,* the listening device must:
- Be assembled in such a way as to allow for the replacement of certain components after normal usage;

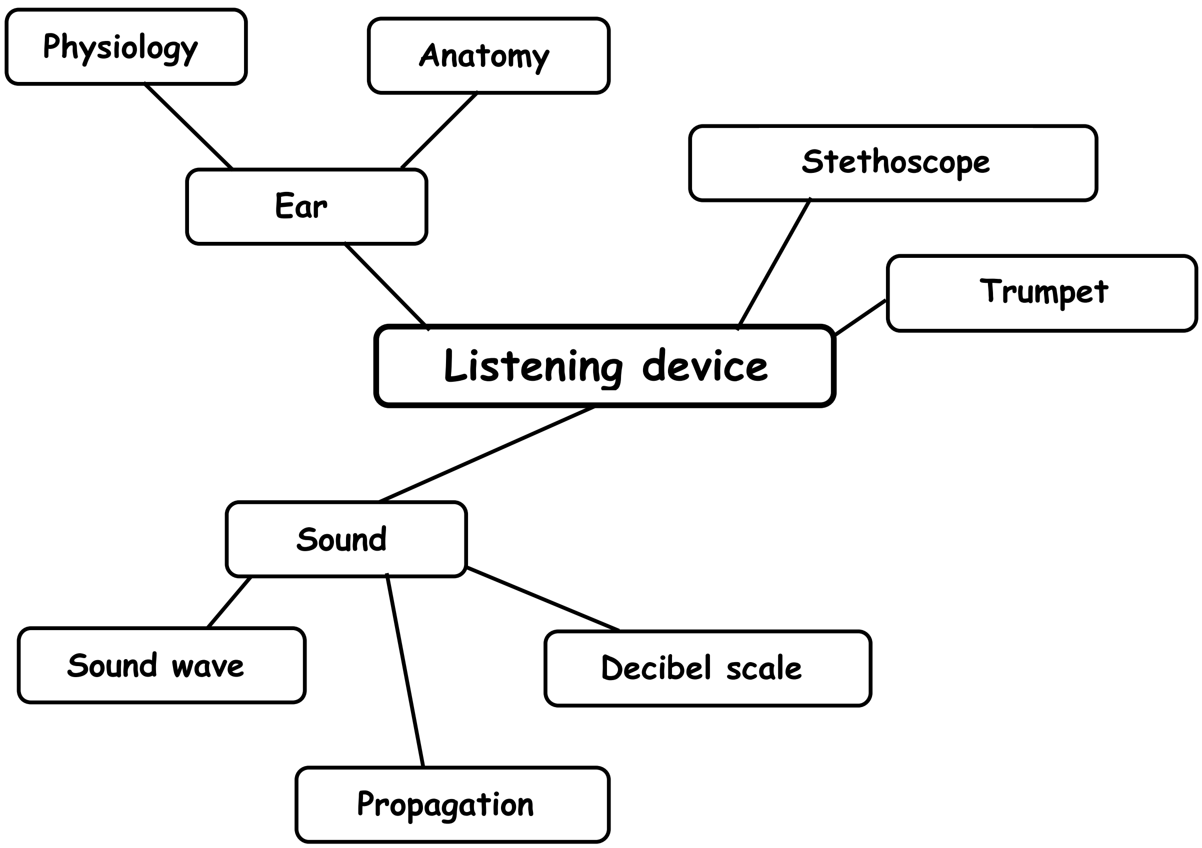
In terms of the *industrial aspect,* the listening device must:
- Be able to be entirely built in a science and technology laboratory of the 2nd cycle of secondary school.
- Be entirely built with the available materials and with the raw materials put at your disposal.

  Note: Pressure-tack and adhesive tape are not allowed as technical connections.

In terms of the *economic aspect,* the listening device must:
- Be cheaper than $3.00

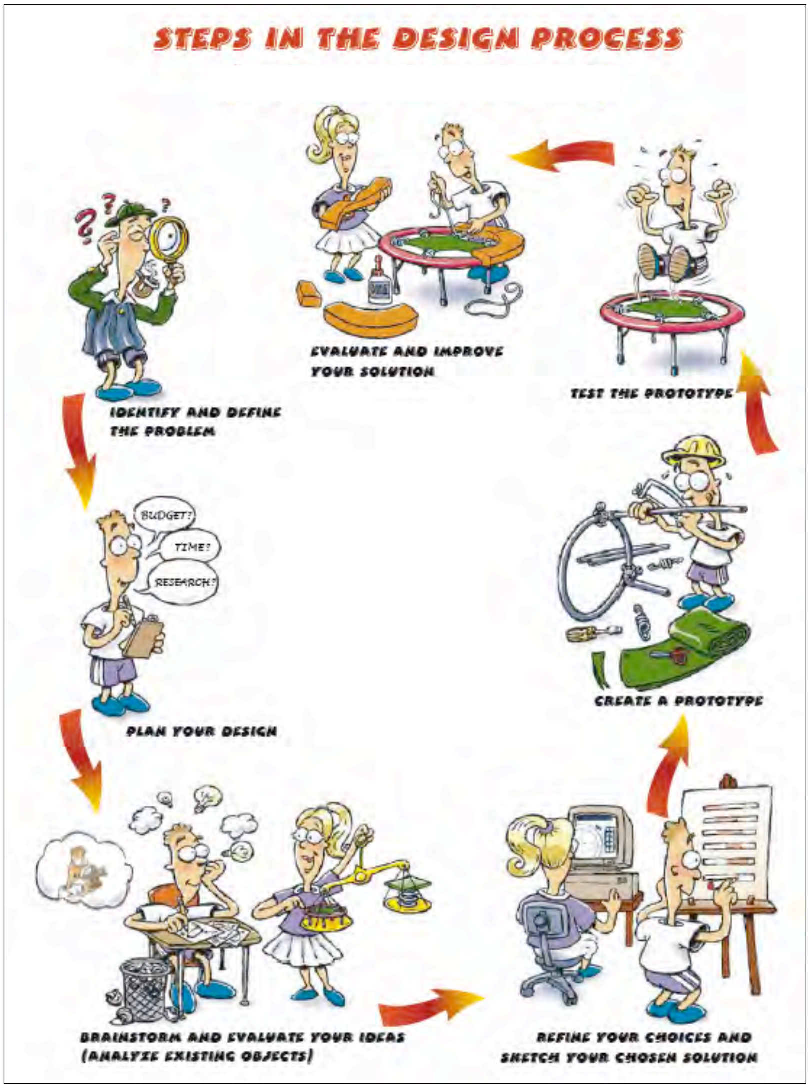
Warm-up period

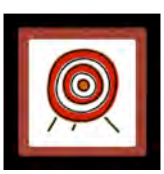
Explorations card for concepts associated to the proposed challenge…



Personal notes:

- The proposed challenge will call upon a process that you know, **the design process.** Though it is not a linear process, a crucial step of the process will be to identify and outline the need to which the technical object must respond.

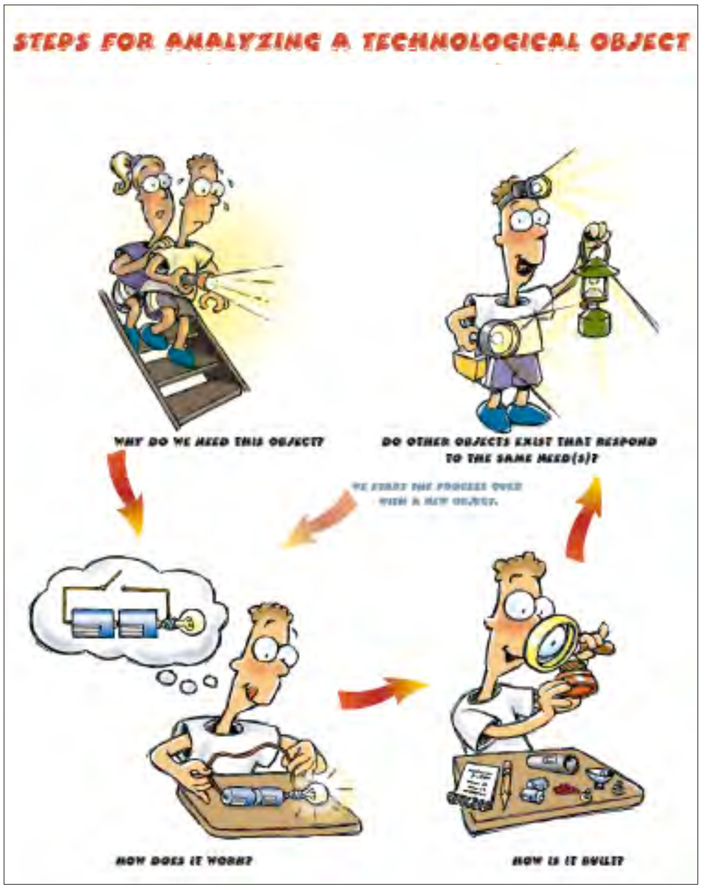




What is the need in the proposed challenge?

When a subject is not well known to you or when ideas do not immediately come to mind, we can turn to existing objects that respond to similar needs. In other words, objects have a similar **global function** to the object to be designed. Perhaps inspiration will come. Understanding of the concepts related to the challenge will definitely come.

We thus suggest that you undertake, step by step, the technological analysis of a stethoscope.



This analysis will not be exhaustive, rather limiting itself only to some aspects of what an analysis can be. Thus, we will linger only on historical, scientific and technological aspects.
In your opinion, why have we identified these three aspects? Justify your answer.

Technological analysis of the stethoscope

When we undertake the technological analysis of an object we put up **boundaries of the analysis** in relation to the reasons for the analysis. In the present case, it is the need to design a listening device that will be the basis for our questioning.

A multitude of questions may come up and as many decisions will have to be made when this type of work is undertaken, even for a simple object – that contains no mechanisms nor many parts – like the stethoscope.

- What need is the basis for its design?
- How has it evolved over time?

Historical aspect

- How does the stethoscope work?
- What scientific concepts come into play?

Scientific aspect

- How de we represent them?
- How is the object made?
- How do we represent it while respecting the conventions of schematic representation?

Technological aspect

1. What is a stethoscope used for? (global function)

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History

The stethoscope was invented in 1816, in France by Doctor **René Laennec.** At the time, the stethoscope looked like a trumpet (a bunch of papers rolled up). It allowed the doctor's ear to be distanced from the patient for reasons of modesty. Later, Laennec built several models out of wood.

Around 1830, the pavilion (the patient's side) will be connected to the earphone by a flexible tube, but the rigid model persists for several decades.

Until then, the stethoscope had been equipped with a single earpiece. It is only in 1851 that the binaural (with two earpieces) model appears.

2. From the presented pictures of 19th century stethoscopes, choose two that present interesting characteristics for your design. Justify your choices.

Illustration 1
Justification: Name of designer: Design year:
Illustration 2
Justification: Name of designer: Design year:

The contemporary stethoscope

At the beginning of the 1960s, Doctor David Littmann created the stethoscope as we know it today. It is equipped with a double reversible pavilion (metallic part fitted with a membrane) connected by a flexible tube up to the buds that the operator places in his ears. We will observe a similar model. It is equipped with a single pavilion, but its function remains the same.

- One important stage of the analysis consists of naming each of the parts (or pieces) of the technical object to be studied. This ensures that there is a common language and eases communication between the involved participants (designers, technicians, industrialists, labourers, etc.).

3. Name the parts of the stethoscope.

- It might be useful to consult a visual dictionary or books or sites for technical nomenclature to name certain parts.

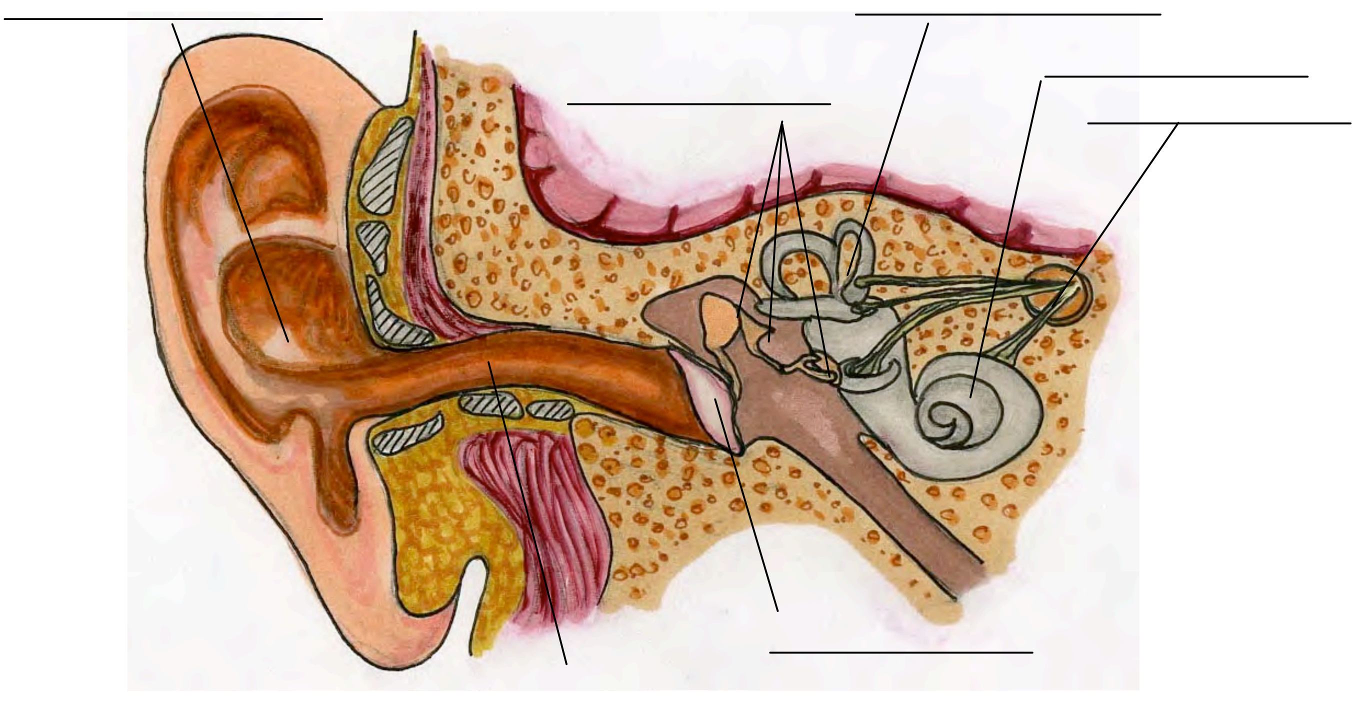
NOMENCLATURE

SOUND AND THE EAR

About sound

The idea that sound is a vibratory phenomenon is rather ancient. A Roman architect is said to have suggested it 2000 years ago.
Sound can be propagated in an environment that reacts elastically and that can therefore transmit vibratory energy.

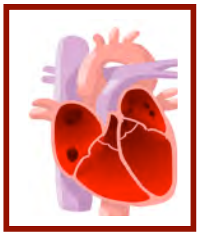
4. Identify each of the parts of the ear on the diagram below.



5. How de we hear? (Suggestions for video sequences at the following addresses): www.youtube.com/ 1.webloc and www.youtube.com/.webloc)

Heartbeats

The heart is a pump which circulates blood throughout the body. The sound we hear is caused by heart valves closing. Look at the following animation carefully.



http://www2.cslaval.qc.ca/cdp/UserFiles/File/previews/coeur_ii.swf

Since the human body is made mainly of liquids and elastic tissue (we will come back to this in the capsule about the study of sound), the pavilion of the stethoscope captures this sounds and transmits it to the user's ear.

6. Carry out diagrams of the construction of the stethoscope.

The technological aspect of the analysis consists in explaining how the technical object is made. To ease communication, there is uniformity in the rules of diagramming. In the construction diagram, the object is represented in a simplified manner; we **identify the parts; name the materials and identify the links as well as their characteristics.**

- We suggest that you carry out two diagrams, the first for the side with the ear buds and the second for the pavilion side, thus simplifying the study. It may be useful to enlarge some of the parts of the object that may be too small to be adequately represented in a set diagram.

Note: It may be useful to refer to the leaflet regarding diagramming.

Construction diagram (« user » side)

Construction diagram (« patient side »)

Sound: its nature and its method of propagation

View the following video sequence:

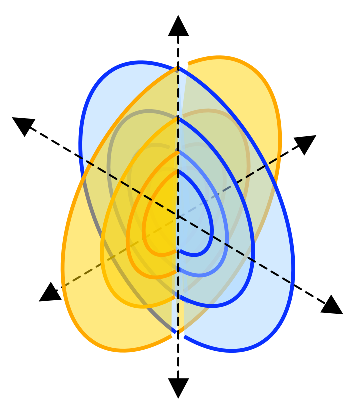
http://www.youtube.com/watch?v=AaqLl1Gg14c

What is sound?

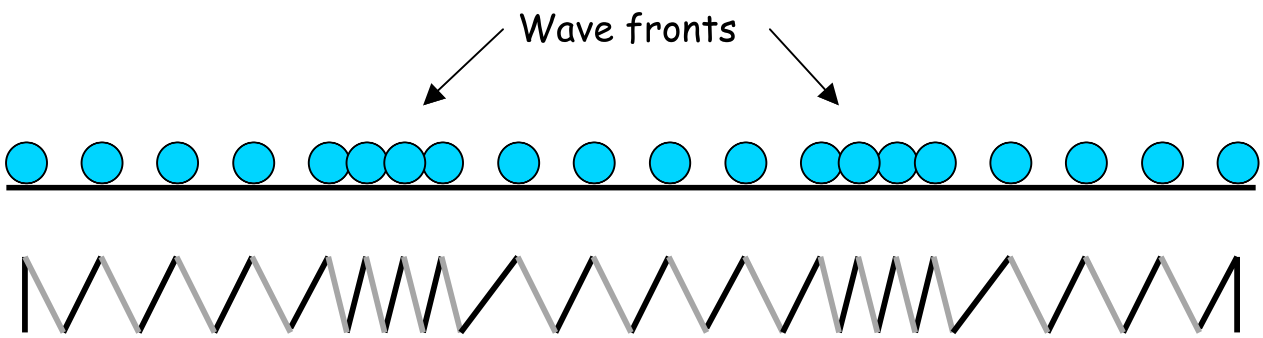
To begin with, a more scientific way of referring to sound is to use the expression "sound waves". This type of wave is in fact a deformation of the center that spreads starting from one point and transports a certain amount of energy.

We often use analogies to capture the essence of what this wave truly is. The most popular analogy refers to waves on the surface of water. This way of imagining sound waves is not without interest. Indeed, the sound emitted from a source spreads in the air somewhat like circular waves created by an object dropped into water. Another interesting analogy between the two phenomena is that matter is not displaced with the wave. In the case of the wave in the water, water molecules go up and down without any horizontal displacement. In the case of sound, the particles of matter gently oscillate in a certain position and also do not move with the sound wave.

This analogy is, however, limited. In fact, waves at the surface of the water are displaced on a surface (in two dimensions). Sound in the air is propagated in space (in three dimensions). In two dimensions, the waves are represented by concentric circles (having the same center), while in three dimensions, they are represented by concentric spheres.

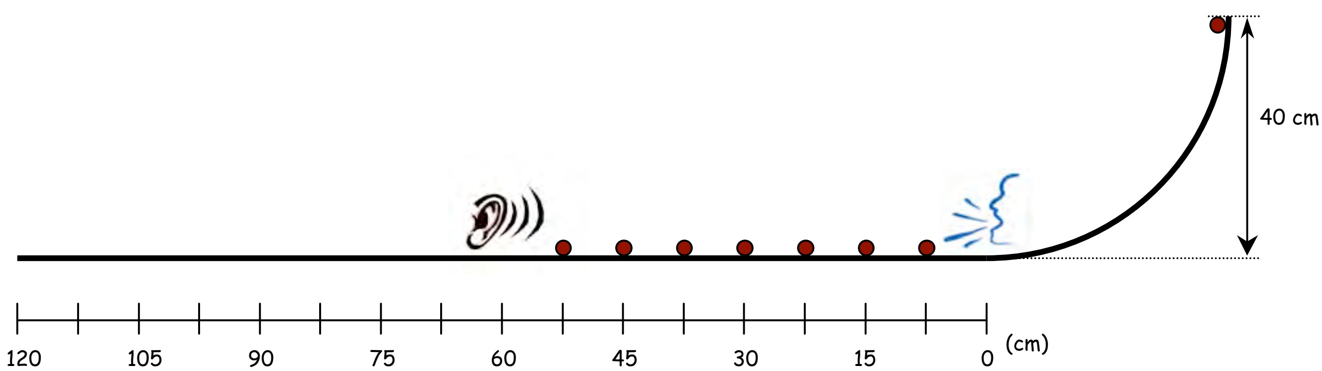


The most important limitation of the analogy with waves in the water comes from the fact that the sound wave is a compression wave. The matter which supports the sound wave does not go up and down as is the case with waves in water. Rather, the particles of matter move closer and farther from one another. An interesting analogy to imagine this phenomenon is the propagation of waves in a compressed spring. On the drawing below, the zones where the spring is compressed represents the areas where, in the air, the particles are very close to one another. These zones are called "wave fronts" and by analogy with the water these fronts are represented by the top of the waves.



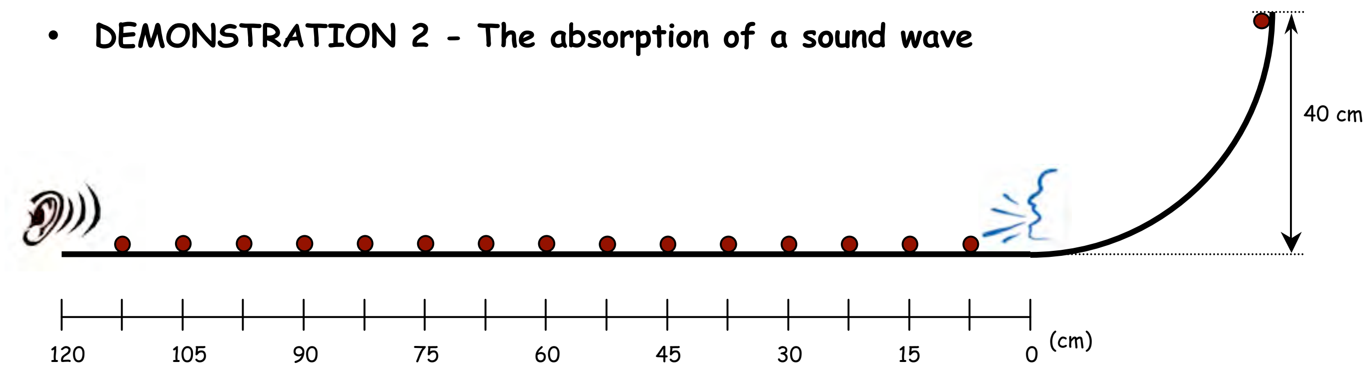
We could also enlarge the air molecules and represent them with marbles.

- **DEMONSTRATION 1 - propagation of a sound wave between two points**



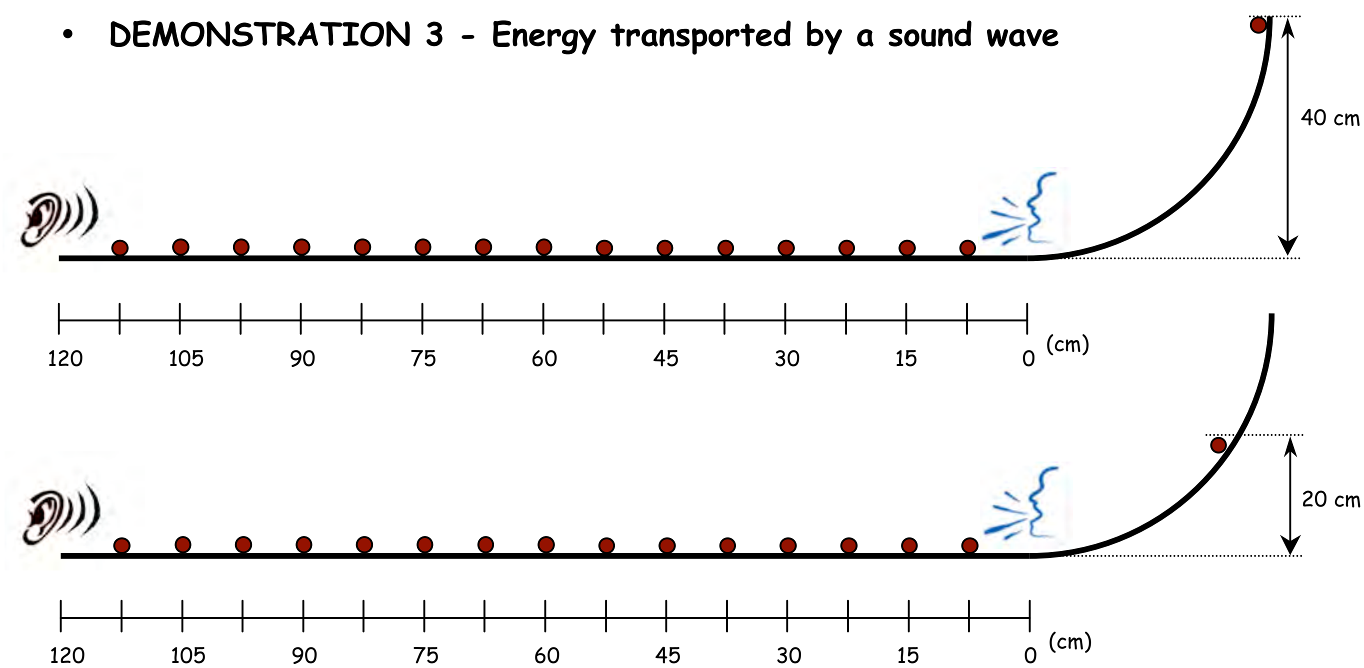
Personal notes:

- **DEMONSTRATION 2 - The absorption of a sound wave**



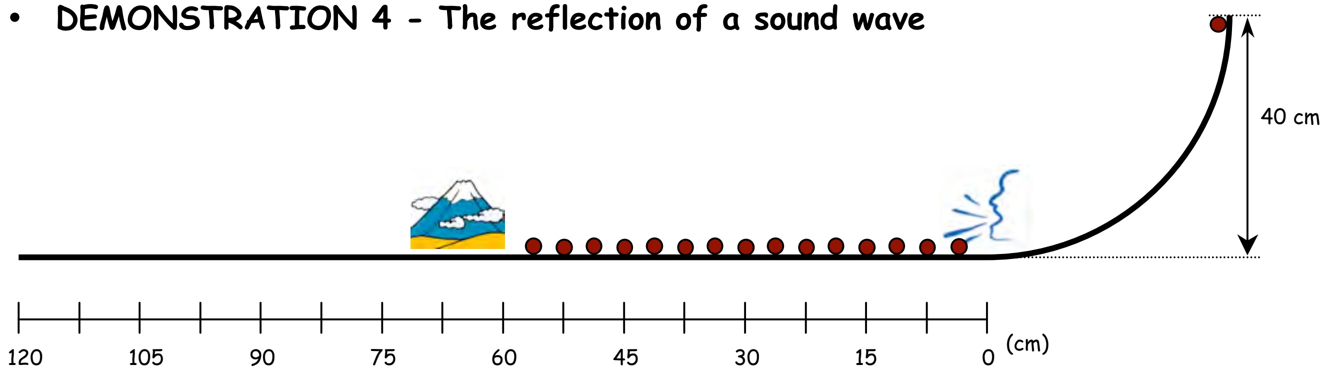
Personal notes:

- **DEMONSTRATION 3 - Energy transported by a sound wave**



Personal notes:

- **DEMONSTRATION 4 - The reflection of a sound wave**



Personal notes:

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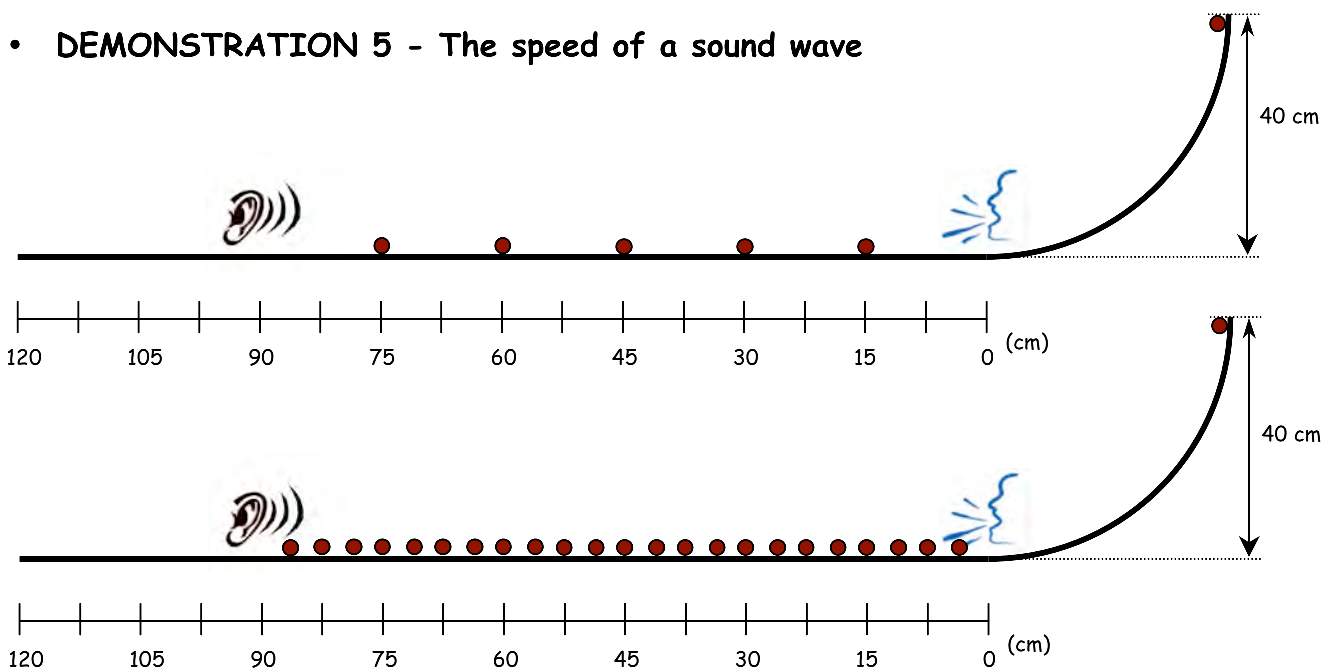
- **DEMONSTRATION 5 - The speed of a sound wave**



Personal notes:

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The Decibel scale

Qualifying a sound heard by an individual is no easy task. Indeed, different people will describe and perceive sounds different ways. Think of certain types of music toward which many parents don't have the same perception as their children!

We may speak of sound or noise, depending on whether the sound is pleasing to the ear or not. Thus, we will qualify as noise a sound that is unpleasant to us. A jack-hammer is a good example of noise that is unanimous.

Let's remember that we can distinguish between high or low sounds, soft or loud. It thus becomes difficult to classify all these different sounds and becomes imperative to have a system to do so.

It is in honour of **Alexander Graham Bell,** a Canadian well known for that most popular of inventions among teenagers, the telephone, that the unit of measure for sound is named the **bel (B) or the more often used decibel (dB).**

Mr. Bell had spent a lot of time working among deaf people. His mother and his wife were both deaf. He had undertaken work to transform sound into an electrical signal, whence the invention of the telephone[1].

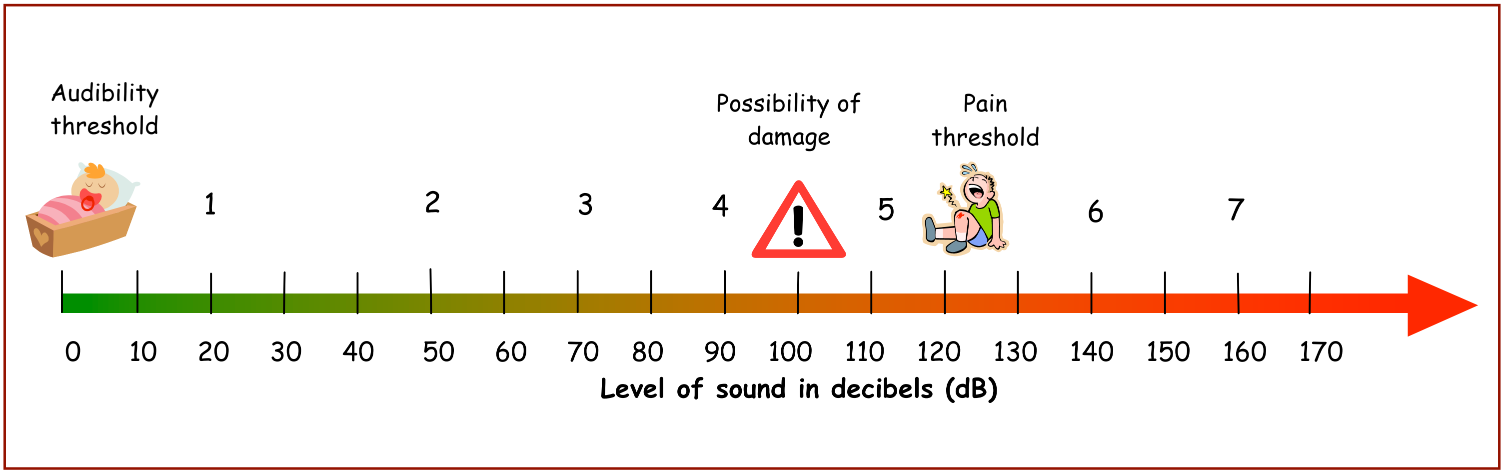
Noise levels are measured on the decibel scale. It takes into account both the **frequency** and the **intensity of the sound.** Indeed, a high and low sound of the same intensity seems different because the human ear perceives high frequencies better than low frequencies.

The decibel scale is a logarithmic scale. This means that a leap of 3 decibels doubles the sound level while a leap of 10 decibels multiplies the sound level by 10.

[1] Alexander Graham Bell - http://en.wikipedia.org/wiki/Alexander_Graham_Bell

The zero on the scale has been set at the threshold of a sound audible to a very young child.

The decibel scale



Associate the following sounds with the numbers 1 through 7 on the decibel scale.

A. Rock concert ❑
B. Lawn mower ❑
C. Gun fire ❑
D. Normal conversation ❑
E. Wind in branches ❑
F. Permanent damage ❑
G. Vacuum cleaner ❑

Function and principle of operation of a stethoscope

Now that you have looked at the construction of the stethoscope and are familiar with sound, complete the following principles diagram, adding explanations relative to the operation of the stethoscope.

Global function of the stethoscope:

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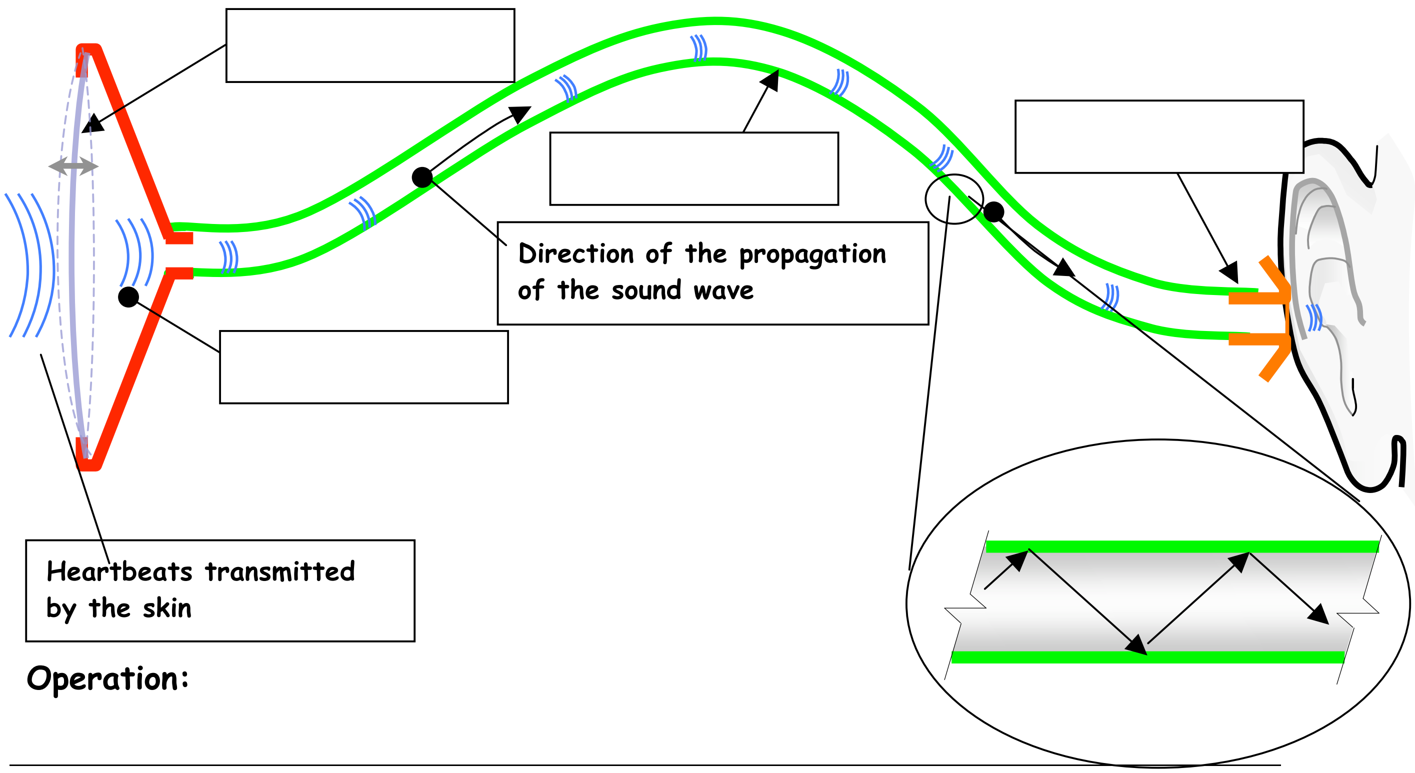

Operation:

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Spy designers, you are now ready to take up the challenge!

1. Using your scientific and technological knowledge, explain what you intent to do to be successful.

2. Illustrate you initial ideas using a principles diagram. Add comments as needed.

Initial ideas	Comments and explanations

3. Establish a list of tools, equipment and materials envisioned to carry out your prototype.

Necessary equipment and materials	Necessary tools

4. Note and justify all decisions or adjustments made during the design process.

Decisions and adjustments	Justifications

5. Carry out the construction diagram of your listening device

Construction diagram

6. Testing

Identify sentence n° _____and transcribe it here.

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7. What aspects are to be improved on your prototype? Justify your response.

- Among the prototypes created in your group are some more efficient than others? Why?

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8. Compare the ancient stethoscope, today's stethoscope and your listening device.

Risks associated to noise, aging and anomalies of the ear.